Report of the visit effected to the USA by Yves Desaubies from February 21 to 29, 2000

Context :

This visit was made possible through a grant from the Office of Naval Research (ONR) (*Visiting Scientist Programme),* in the context of the ARGO project, with the aim to visit West Coast Laboratories to exchange information on the state of development, establish co-operations, and co-ordinate operations in future plans. The programmes in acoustic tomography are also of interest, as our laboratory (Laboratoire de Physique des Océans) is actively engaged in this domain.

Place visited and people met

In Seattle : University of Washington: C.Eriksen, P.Rhines, S.Riser, D.Swift.
Applied Physics Laboratory : B.Dushaw, T.Ewart, B.Howe, M.Gregg, R.Spindel.
Pacific Marine Environment Lab. : P.Freitag, G.Johnson.

In La Jolla : Scripps Institution of Oceanography : R.Davis, K.Lavender, J.Miles, W.Munk, R.Pinkel, D.Roemmich, D.Stammer, P.Worcester.

Programmes

Several programmes involving Autonomous Profiling Floats (APF) are already under way, most notably those undertaken during the Atlantic Circulation and Climate Experiment (ACCE). Some 200 floats have been deployed, most of which are still in operation. Some of the data is available to the general scientific community, some is still considered proprietary by the PI. The groups involved are from WHOI (Owens and Schmitt), Molinari et Garzoli (AOML), R.Davis (SIO) and S.Riser (UW).

At the UW, the current deployments are in the subtropical Atlantic (75 floats) and the Sea of Japan (30 floats). Data are processed in real time and displayed on a WEB site. The data are freely shared with interested scientists (Le Traon for comparison with altimetry; Chassignet for assimilation and validation of MICOM model, for instance).

The US contribution to the ARGO project is organized under the auspices of the NOPP (National Ocean Partnership Programme), which facilitates multi-agency funding. Thus, NOAA, NSF and ONR will contribute to funding the programme. The participants will involve PIs from academia, government laboratories and private industry. The US implementation of ARGO will take place in 3 phases from 2000 to 2005.

The first phase, already funded for FY 2000, is a pilot demonstration, with 55 floats to be deployed in the tropical Atlantic and southeastern tropical Pacific oceans. The partners involved are WHOI, SIO, UW, NOAA, PMEL, Webb Research Corporation, and Seascan Incorporated. D.Roemmich (SIO) is lead PI on this project. The second phase will build on those initial deployments to increase the inventory of ARGO floats in the Atlantic and Pacific oceans. It is anticipated that an additional 130 floats could be deployed in 2001 under that funding.

The third phase will aim for the full implementation, from 2001 to 2005. The US contribution could be of the order of half the global requirement (i.e. 375 floats per year out of

a total of 750). A competitive call for proposal will be issued. Funding will support not only floats purchase, but also data acquisition, processing, and scientific analysis.

All planning will be done in the international context (the International ARGO Science Team) to co-ordinate deployment and to achieve a truly global array. There is clearly ample opportunity for collaboration with the French and European programmes, which will be focused on the North Atlantic ocean, starting in 2001.

In other oceans, R.Davis (SIO) monitors some 700 floats (mostly ALACE, which do not have a temperature and salinity profiling capability, but report only their position), including some 100 SOLO profiling floats, in all oceans. Some of the floats in the Labrador Sea have blades allowing vertical velocity determination. K.Lavender showed interesting analysis in terms of trajectories and dynamic height. The floats have allowed the observation of westward flowing counter-current south of Greenland.

Data assimilation

Meeting with D.Stammer (lead PI) gave an opportunity to hear about another NOPP funded programme, *A Consortium for Ocean Circulation and Climate Estimation*, which aims is "*to bring ocean state estimation from its current experimental status to a practical and quasi-operational tool for studying large-scale ocean dynamics, for examining the ocean's role in climate variability, and for quantitatively designing long-term observational strategies*". The central technical goal is a complete global-scale ocean state estimation over at least the 15 year period 1985-2000 at 1/4 resolution with a complete error description and regional refinements to support CLIVAR and GODAE needs. The partnership will combine all available and anticipated large-scale data sets - including TOPEX/POSEIDON, TOGA-TAO, high-resolution VOS XBT/XCTD, profiling floats, and drifters - with the dynamics embodied in a general circulation model to estimate the time-evolving, three-dimensional physical state of the full oceanic circulation. Results will be evaluated by the consortium in collaboration with the community and made available to all, fostered through an educational and visitor program.

Tomography

Discussions in Seattle (APL/UW) and La Jolla (IGPP/SIO), with Dushaw, Howe, Munk and Worcester covered various projects. The ATOC long range transmission experiment has suffered greatly from adverse publicity and controversy. Eventually, no adverse effects on marine life was detected, but nonetheless, in the words of Munk: "we won a battle, but lost the war !". The sound source off Monterey must be removed; efforts are underway to obtain authorization to at least maintain the cable. A time-consuming process of permit request is pursued to re-activate the sound source at Kauaï for a five year extension. Receptions will be at extant SOSUS stations; efforts are made to develop and deploy additional autonomous receivers at various locations.

The HOME project (Hawaï Ocean Mixing Experiment) is a multiyear NSF-funded project, with a significant tomography component. The overall goal is to study the role of bathymetry on ocean mixing, in particular the process of tidal energy conversion from barotropic to barclinic. A four mooring acoustic array will be deployed successively in two locations (North and South of the island), for 3- months periods, to observe and quantify tidal energy fluxes. Several other types of observation programmes (internal waves, fine-structure) will be conducted by other investigators, from FLIP (R.Pinkel: backscatter sonars, fast-repeat CTD), or with micro- and fine- structure profilers (M.Gregg, T.Sanford), for a complete de-

scription of the mixing processes. Meeting with W.Munk gave an opportunity to hear about his recent work on tidal energy dissipation and mixing.

Other recently completed projects involving acoustics include the acoustic monitoring of the Gibraltar strait (high frequency), in collaboration with U.Send (IfM/Kiel in Germany), and a long range scattering transmission experiment (low frequency) in the North pacific (NPAL: North Pacific Acoustic Lab, a one year deployment of 4 moorings). Analysis is under way.

Further experiments are planned in the Kuroshio extension region (KESS, in collaboration with the Japanese) and a continuation of the Gibraltar monitoring has been submitted as a joint proposal to the NSF and the European Union. The latter would involve a system cabled to shore, with hydrophones at several depth on both sides of the channel, allowing real time monitoring, and resolution of the flows entering and exiting the Mediterranean sea.

Operational oceanography

A visit to PMEL (Seattle) was an opportunity to see first hand how a truly operational ocean observing system is operated. The TAO network of surface buoys is maintained from PMEL, from ship cruises, hardware maintenance, instrument building and calibration, to data validation and distribution, and maintenance of a web site for data access. About 30 people are working on this programme. Greg Johnson, at PMEL, is working on the development of algorithms for automatic correction of salinity drift on autonomous floats.

Technology and instrumentation

There was ample opportunities during the visits to see state of the art instrumental developments. R.Spindel , Director, gave me a tour of APL and the developments on medical instrumentation and underwater acoustics. Of great interest was the glider, developed in collaboration with C.Eriksen. A similar instrument is developed at SIO, in collaboration with WHOI (B.Owens). Present trial operations are limited to Puget Sound (Whidbey Island) because of communication problems: the communication link has been originally designed with Iridium system, which is now bankrupt. The cellular phone alternative limits operations within coastal range; the SIO model uses ORBCOM. Nonetheless, this is a very promising and impressive technology, since it allows navigation of the probe, either for long range missions, or for virtual mooring applications. A proposal is for using glider technology for boundary arrays around the Pacific rim during PBECS (Pacific Basin Extended Climate Studies, a CLIVAR contribution).

Specific discussions and exchanges were held on the operations and performances of the different types of profiling floats: the SOLO (built at SIO), and the APEX (a new version of the P-ALACE, built by WRC), and their associated sensors for pressure, temperature and conductivity (Falmouth Scientific Instruments and SeaBird Electronics). It is a very active field, with the instruments evolving continuously in response to users demands and competition driving prices down. The purchase price of a float, with SeaBird sensors is now quoted as $ 13 000.

Another exciting development is the DEOS (Dynamics of Earth and Ocean Systems) which would include about 20 large moored surface buoys, with ample power supply for observatories including OBS, surface flux sensors, and other instrumentation such as tomography. The associated Neptune project (APL and SIO) would lay fiber optics cables around the Juan de Fuca Plate to build a localized instrumented network.

R.Pinkel (SIO) has just completed field trials of a new long range (1000 m) VM-ADCP (Vessel-Mounted Acoustic Doppler Current Profiler) installed on the RV/R.Revelle.

This instrument would operate on an operational basis during transits and operations, and made widely available.

Acknowledgments

It is not possible to account here for the tenor of all the discussions and exchanges held during the visits. They helped prepare the second meeting of the International ARGO Science Team, which was held the following week (March 7-9) in Southampton, and came timely in view of the major deployments of floats anticipated for 2001.

I thank all my colleagues who extended a graceful welcome during my visits. I am very grateful to the ONR International Field Office, and in particular to A.Weinstein, for making this fruitful visit possible.